

CLAIMS

1. A method for utilizing spare bandwidth resulting from the use of a transition-limiting code in a multi-level signaling system, the transition-limiting code having a characteristic
5 wherein a signal level is periodically unused, the method comprising the step of:

modifying the transition-limiting code such that the periodically unused signal level is used to represent additional information.

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2. The method of claim 1, wherein the transition-limiting code is formed by encoding digital values represented by sets of N bits to provide corresponding sets of P symbols, wherein N is greater than P.

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3. The method of claim 2, wherein each set of P symbols is formed with Q bits, wherein Q is greater than N.

4. The method of claim 3, wherein $N = 8$ and $Q = 10$.

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5. The method of claim 4, wherein each symbol represents two bits.

6. The method of claim 1, wherein the step of modifying
comprises:

changing the logic state of at least one codeword bit in
the transition-limiting code.

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7. The method of claim 1, wherein the additional information
comprises one or more of control information, data information,
error information, framing information, and synchronization
information.

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8. The method of claim 1, further comprising the step of:
transmitting the modified transition-limiting code.

9. The method of claim 8, wherein the modified transition-
15 limiting code is transmitted at four signal levels on a single
transmission medium.

10. The method of claim 9, wherein the single transmission
medium comprises a single electrical conductor.

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11. The method of claim 9, wherein the single transmission
medium comprises a differential pair of electrical conductors.

12. The method of claim 9, wherein the single transmission medium comprises an optical fiber.

13. The method of claim 8, further comprising the steps of:

5 receiving the transmitted modified transition-limiting code; and

detecting the additional information in the received modified transition-limiting code.

10 14. The method of claim 13, further comprising the step of:

removing the additional information from the received modified transition-limiting code so as to return the modified transition-limiting code to an original unmodified state.

15 15. The method of claim 14, further comprising the step of:

decoding the original transition-limiting code after the additional information is removed.

16. The method of claim 8, wherein the transition-limiting code

20 has a further characteristic wherein a plurality of signal levels are periodically unused, wherein one or more of the plurality of periodically unused signal levels is restricted from being used to represent additional information at least at

certain times, further comprising the steps of:

receiving the transmitted modified transition-limiting
code; and

detecting the use of a signal level that has been

5 restricted.

17. The method of claim 16, further comprising the step of:

generating an error signal based at least in part upon the
detected restricted signal level use.

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18. An apparatus for utilizing spare bandwidth resulting from
the use of a transition-limiting code in a multi-level signaling
system, the transition-limiting code having a characteristic
wherein a signal level is periodically unused, the apparatus

15 comprising:

a modifier for modifying the transition-limiting code such
that the periodically unused signal level is used to represent
additional information.

20 19. The apparatus of claim 18, wherein the transition-limiting
code is formed by encoding digital values represented by sets of
N bits to provide corresponding sets of P symbols, wherein N is
greater than P.

20. The apparatus of claim 19, wherein each set of P symbols is formed with Q bits, wherein Q is greater than N.

5 21. The apparatus of claim 20, wherein $N = 8$ and $Q = 10$.

22. The apparatus of claim 21, wherein each symbol represents two bits.

10 23. The apparatus of claim 18, wherein the modifier modifies the transition-limiting code by changing the logic state of at least one codeword bit in the transition-limiting code.

24. The apparatus of claim 18, wherein the additional
15 information comprises one or more of control information, data information, error information, framing information, and synchronization information.

25. The apparatus of claim 18, further comprising:
20 a transmitter for transmitting the modified transition-limiting code.

26. The apparatus of claim 25, wherein the modified transition-

limiting code is transmitted at four signal levels on a single transmission medium.

27. The apparatus of claim 26, wherein the single transmission
5 medium comprises a single electrical conductor.

28. The apparatus of claim 26, wherein the single transmission medium comprises a differential pair of electrical conductors.

10 29. The apparatus of claim 26, wherein the single transmission medium comprises an optical fiber.

30. The apparatus of claim 25, further comprising:
a receiver for receiving the transmitted modified
15 transition-limiting code; and
a detector for detecting the additional information in the received modified transition-limiting code.

31. The apparatus of claim 30, wherein the detector also
20 removes the additional information from the received modified transition-limiting code so as to return the modified transition-limiting code to an original unmodified state.

32. The apparatus of claim 31, further comprising:

a decoder for decoding the original transition-limiting code after the additional information is removed.

5 33. The apparatus of claim 25, wherein the transition-limiting code has a further characteristic wherein a plurality of signal levels are periodically unused, wherein one or more of the plurality of periodically unused signal levels is restricted from being used to represent additional information at least at
10 certain times, further comprising:

a receiver for receiving the transmitted modified transition-limiting code; and

a detector for detecting the use of a signal level that has been restricted.

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34. The apparatus of claim 33, wherein the detector also generates an error signal based at least in part upon the detected restricted signal level use.

20 35. A method for utilizing spare bandwidth resulting from the use of a transition-limiting code in a multi-level signaling system, the method comprising the steps of:

encoding digital values using a transition-limiting code,

the transition-limiting code having a characteristic wherein a
signal level is periodically unused; and

modifying the transition-limiting code such that the
periodically unused signal level is used to represent additional
5 information.

36. The method of claim 35, further comprising the step of:
transmitting the modified transition-limiting code.

10 37. The method of claim 36, further comprising the steps of:
receiving the transmitted modified transition-limiting
code; and

detecting the additional information in the received
modified transition-limiting code.

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38. The method of claim 37, further comprising the step of:
removing the additional information from the received
modified transition-limiting code so as to return the modified
transition-limiting code to an original unmodified state.

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39. The method of claim 38, further comprising the step of:
decoding the original transition-limiting code after the
additional information is removed.

40. The method of claim 36, wherein the transition-limiting code has a further characteristic wherein a plurality of signal levels are periodically unused, wherein one or more of the plurality of periodically unused signal levels is restricted from being used to represent additional information at least at certain times, further comprising the steps of:

receiving the transmitted modified transition-limiting code; and

detecting the use of a signal level that has been restricted.

41. The method of claim 40, further comprising the step of:

generating an error signal based at least in part upon the detected restricted signal level use.

42. An apparatus for utilizing spare bandwidth resulting from the use of a transition-limiting code in a multi-level signaling system, the apparatus comprising:

an encoder for encoding digital values using a transition-limiting code, the transition-limiting code having a characteristic wherein a signal level is periodically unused; and

a modifier for modifying the transition-limiting code such that the periodically unused signal level is used to represent additional information.

5 43. The apparatus of claim 42, further comprising:

a transmitter for transmitting the modified transition-limiting code.

44. The apparatus of claim 43, further comprising:

10 a receiver for receiving the transmitted modified transition-limiting code; and

a detector for detecting the additional information in the received modified transition-limiting code.

15 45. The apparatus of claim 44, wherein the detector also removes the additional information from the received modified transition-limiting code so as to return the modified transition-limiting code to an original unmodified state.

20 46. The apparatus of claim 45, further comprising:

a decoder for decoding the original transition-limiting code after the additional information is removed.

47. The apparatus of claim 43, wherein the transition-limiting code has a further characteristic wherein a plurality of signal levels are periodically unused, wherein one or more of the plurality of periodically unused signal levels is restricted from being used to represent additional information at least at certain times, further comprising:

a receiver for receiving the transmitted modified transition-limiting code; and

a detector for detecting the use of a signal level that has been restricted.

48. The apparatus of claim 47, wherein the detector also generates an error signal based at least in part upon the detected restricted signal level use.

49. An apparatus for utilizing spare bandwidth resulting from the use of a transition-limiting code in a multi-level signaling system, the transition-limiting code having a characteristic wherein a signal level is periodically unused, the apparatus comprising:

means for modifying the transition-limiting code such that the periodically unused signal level is used to represent additional information; and

means for detecting the additional information in the
modified transition-limiting code.